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Bibliography

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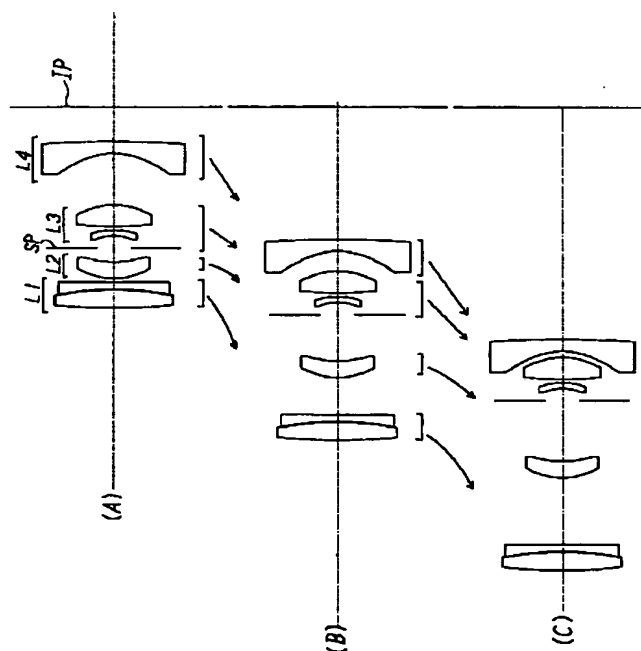
## An epitome

## (57) [Abstract]

[Technical problem] It has four lens groups as a whole, and obtain small 4 group zoom lens which amended the aberration fluctuation accompanying variable power good.

[Means for Solution] the 1st group of refractive power more negative than a body side to order, the 2nd group of positive refractive power, and the 3rd group of positive refractive power -- and It has four lens groups of the 4th group of negative refractive power, and a gap of this 1st group and the 2nd group and a gap of this 2nd group and the 3rd group should increase on the occasion of variable power from a wide angle edge to a tele edge, and while each lens group moves on an optical axis so that a gap of this 3rd group and the 4th group may decrease, this 2nd group and the 4th group should be moving in one.

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## CLAIMS

## [Claim(s)]

[Claim 1] The 1st group of refractive power more negative than a body side to order, the 2nd group of positive refractive power, the 3rd group of positive refractive power, And have four lens groups of the 4th group of negative refractive power, and a gap of this 1st group and the 2nd group and a gap of this 2nd group and the 3rd group increase on the occasion of variable power from a wide angle edge to a tele edge. A zoom lens characterized by this 2nd group and the 4th group moving in one while each lens group moves on an optical axis so that a gap of this 3rd group and the 4th group may decrease.

[Claim 2] It is the zoom lens of claim 1 which said 4th group consists of a single negative lens which turned a concave surface to a body side, and is characterized by at least one lens side of this negative lens being the aspheric surface of a configuration where negative refractive power becomes weak as it goes to a lens periphery from a lens center.

[Claim 3] Said 3rd group is the zoom lens of claim 1 characterized by having at least one aspheric surface.

[Claim 4] Said 3rd group is the zoom lens of claim 1 characterized by having drawing which moves in one in connection with variable power.

[Claim 5] A zoom lens of claim 4 characterized by moving said 3rd group and performing a focus.

[Claim 6] A zoom lens of claim 1-5 characterized by the whole of the 4th group moving to a body side from said 1st group in the case of variable power from a wide angle edge to a tele edge given in any 1 term.

[Claim 7] A zoom lens of claim 1-6 characterized by satisfying conditions which become  $1.1 < M1 - M2 < 1.6$  when movement magnitude of said 1st group and 2nd group is respectively set to M1 and M2 on the occasion of variable power from a wide angle edge to a tele edge given in any 1 term.

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DETAILED DESCRIPTION

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## [Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the zoom lens excellent in the portability aiming at shortening of a lens overall length (distance from the 1st lens side to the image surface) while attaining extensive field angle-ization of a photography field angle especially about the zoom lens of an extensive field angle by the suitable small high variable power for a lens shutter camera, a video camera, etc.

[0002]

[Description of the Prior Art] In the lens shutter camera, the video camera, etc., the small zoom lens with a short lens overall length is demanded with the miniaturization of a camera recently.

[0003] The taking lens with which the miniaturization of a \*\*\* camera is progressing and especially a lens shutter camera is equipped in it by development of circumference technology,

such as an electrical circuit for a zoom drive, etc. is also high variable power, and the compact zoom lens is demanded.

[0004] Conventionally, the so-called 2 group zoom lens which consists of two lens groups, positive and negative refractive power, as a zoom lens for lens shutters was in use. since this 2 group zoom lens has a lens configuration and the simple migration device at the time of variable power -- the miniaturization of a camera -- and it is low cost comparatively -- etc. -- there is an advantage.

[0005] However, in order to have to perform a variable power operation only by one lens group, the variable power ratio is about 1.6 to 2 times, and it becomes difficult to maintain high optical-character ability at the same time expanding a variable power ratio by force causes enlargement of a lens system.

[0006] The 1st group is divided into two lens groups of positive refractive power on the basis of 2 group zoom lens, and 3 group zoom lens which aimed at high variable power-ization as 3 group configurations of positive, positive, and negative refractive power as a whole is proposed by JP,3-282409,A, JP,4-37810,A, JP,4-76511,A, etc.

[0007] however, this lens group configuration -- for example, the half-field angle of 35 degrees or more -- extensive -- if it is going to attain a field angle zoom lens system, change of the entrance pupil location at the time of variable power will become large. For this reason, in case high variable power-ization is attained, it becomes very difficult to suppress the aberration fluctuation by variable power.

[0008] In addition, by multi-lens grouping, the half-field angle of a wide angle edge is made into about 38 degrees, a variable power ratio is made into about 3.5 times, and the zoom lens which attained formation of an extensive field angle and high variable power-ization is proposed by JP,2-72316,A and JP,3-249614,A.

[0009] However, both these zoom lens systems have front \*\*\*\* and a large-sized lens overall length, and are not necessarily enough as a taking lens of a compact camera.

[0010] In case it applies to the camera which uses especially an external finder, there is a trouble that a lens barrel will cover the photography visual field of a finder, at the time of a wide angle edge. Moreover, as a result, the trouble of giving finder arrangement and a limit of the gestalt of a camera is also produced.

[0011] Moreover, it consists of four lens groups of negative, positive, and positive and negative refractive power sequentially from a body side, and 4 group zoom lens of a high variable power ratio is comparatively proposed by JP,4-237009,A with the extensive field angle. However, this 4 group zoom lens had much lens number of sheets, and had the orientation for front \*\*\*\* to increase.

[0012] Moreover, although 4 group zoom lens proposed by JP,64-15610,A had the 3-about variable power ratio, a photography field angle was not necessarily enough.

[0013]

[Problem(s) to be Solved by the Invention] High variable power-ization is attained, the movement magnitude of each lens group for obtaining a predetermined variable power ratio decreasing, and attaining shortening of a lens overall length, if the refractive power of each lens group is generally strengthened in a zoom lens. However, if the refractive power of each lens group is only strengthened, in case the aberration fluctuation accompanying variable power will become large and raise in variable power and extensive field angle-ization will be attained especially, the trouble that it becomes difficult to obtain optical-character ability with a good rear spring supporter is in all variable power ranges.

[0014] constituting this invention from four lens groups as a whole, and setting up appropriately migration conditions, refractive power, etc. of each lens group in variable power -- the photography field angle of a wide angle edge -- about 70 degrees and a variable power ratio -- all the variable power ranges that are about 3.0 -- a rear spring supporter -- it aims at offer of a zoom lens with high optical-character ability.

[0015]

[Means for Solving the Problem] The 1st group of refractive power more negative than a body side to order in a zoom lens of this invention, the 2nd group of positive refractive power, It has

four lens groups of the 3rd group of positive refractive power, and the 4th group of negative refractive power. On the occasion of variable power from a wide angle edge to a tele edge, a gap of this 1st group and the 2nd group and a gap of this 2nd group and the 3rd group increase, and while each lens group moves on an optical axis so that a gap of this 3rd group and the 4th group may decrease, this 2nd group and the 4th group are characterized by moving in one.

[0016]

[Embodiment of the Invention] Drawing 1 - drawing 3 are the lens cross sections of the numerical examples 1-3 of this invention respectively. In drawing 1 - drawing 3, in (A), a wide angle edge and (B) show middle, and (C) shows the tele edge. Drawing 4 - drawing 6 are [ many aberration drawings of the numerical example 2 of this invention, drawing 10 - drawing 12 of many aberration drawings of the numerical example 1 of this invention, drawing 7 - drawing 9 ] many aberration drawings of the numerical example 3 of this invention.

[0017] The 1st group of refractive power negative in L1, the 2nd group of refractive power positive in L2, the 3rd group of refractive power positive in L3, and L4 are the 4th group of negative refractive power among drawing. An arrow head shows the migration direction of each lens group at the time of performing variable power from a wide angle side to a looking-far side. SP extracts and IP is the image surface.

[0018] With this operation gestalt, on the occasion of the variable power from a wide angle edge to a tele edge, the gap of the 1st group and the 2nd group and the gap of the 2nd group and the 3rd group increase, and each lens group is moved to the optical-axis up body side so that the gap of the 3rd group and the 4th group may decrease. The miniaturization of the whole lens system is in drawing, this attaining effectively a predetermined variable power ratio and extensive field angle-ization.

[0019] This invention constitutes the 1st group L1 of especially negative refractive power from two lenses of the negative lens with which both the lens side turned the concave surface to the convex positive lens and body side in order from a body side. The 2nd group L2 of positive refractive power is constituted from one lens of the positive lens of the shape of a meniscus which turned the convex to the body side. Meniscus-like the negative lens and both the lens side which turned the convex to the image surface side constitute the 3rd group L3 of positive refractive power from two lenses of a convex positive lens, and the 4th group L4 of negative refractive power consists of one lens of the negative lens of the shape of a meniscus which turned the convex to the image surface side. This securing a predetermined variable power ratio, the aberration fluctuation accompanying variable power was amended good, and high optical-character ability has been obtained over all variable power ranges.

[0020] Moreover, said 4th group consisted of the single negative lens which turned the concave surface to the body side, and at least one lens side of this negative lens was constituted from the aspheric surface of a configuration where negative refractive power becomes weak as it went to the lens periphery from the lens center, it amended the aberration fluctuation accompanying variable power, and has amended aberration outside a shaft, such as a curvature of field and distortion aberration, good especially. He is trying for \*\*\*\* 3 group to have at least one aspheric surface. This has amended the aberration fluctuation in the case of variable power and a focus good.

[0021] Drawing SP made it move in one with the 3rd group in connection with variable power, and has prevented increase of the lens outer diameter of each lens group. \*\*\*\* 3 group is moved, a focus is performed and aberration fluctuation in the case of a focus is lessened.

[0022] In the case of the variable power from a wide angle edge to a tele edge, as the whole of the 4th group moves to a body side from said 1st group, shortening of the lens overall length in a wide angle edge is attained, and the miniaturization of the whole camera at the time of un-using it is in drawing.

[0023] When movement magnitude of said 1st group and 2nd group is respectively set to M1 and M2 on the occasion of the variable power from a wide angle edge to a tele edge, it is  $1.1 < M1/M2 < 1.6$ . ..... (1)

He is trying to satisfy the becoming conditions.

[0024] Conditional expression (1) is a thing for amending a curvature of field good, mainly

attaining shortening of a lens overall length about the ratio of the movement magnitude of the 1st group accompanying variable power, and the 2nd group. If the movement magnitude of the 1st group increases compared with the 2nd group exceeding the upper limit of conditional expression (1), since the lens overall length in a tele edge will become long, it is not good. [0025] Moreover, if the movement magnitude of the 1st group decreases exceeding the lower limit of conditional expression (1), it will become difficult to amend the aberration fluctuation accompanying variable power, especially fluctuation of the chromatic aberration of magnification good.

[0026] In addition, it is the numerical range of conditional expression (1) still more preferably  $1.2 < M1/M2 < 1.4$  ..... (1a)

\*\* -- it is good to set up like.

[0027] Next, the numerical example of this invention is shown. a numerical example -- setting --  $R_i$  -- a body side -- the  $i$ -th lens thickness and an air gap,  $n_i$  and  $\nu_i$  are the radius of curvatures of the  $i$ -th lens side, and  $D_i$  is the refractive index and the Abbe number of glass of the  $i$ -th lens in order from an each body side in a body side. Moreover, an aspheric surface configuration is [0028], when the radius of curvature of the core of a lens side was set to  $R$ , the  $X$ -axis was set as the direction of an optical axis (travelling direction of light), a  $Y$ -axis is set as an optical axis and a perpendicular direction and  $B$ ,  $C$ ,  $D$ , and  $E$  are respectively made into an aspheric surface coefficient.

[Equation 1]

$$X = \frac{(1/R) Y^2}{1 + \sqrt{1 - (1+K) (Y/R)^2}} + B Y^4 + C Y^6 + D Y^8 + E Y^{10}$$

It expresses with the becoming formula. Moreover, "e-X" means "x10-X."

[0029]

[External Character 1]

## 数値実施例 1

 $f = 31.10 \sim 89.16$   $F \#0 = 3.91 \sim 8.87$   $2\omega = 69.7 \sim 27.3$ 

R 1 = 113.17	D 1 = 3.87	N 1 = 1.516330	$\nu$ 1 = 64.2
R 2 = -56.62	D 2 = 0.16		
R 3 = -51.75	D 3 = 1.50	N 2 = 1.805181	$\nu$ 2 = 25.4
R 4 = -1251.5	D 4 = 可変		
R 5 = 13.85	D 5 = 3.47	N 3 = 1.621021	$\nu$ 3 = 35.3
R 6 = 20.28	D 6 = 可変		
R 7 = 絞リ	D 7 = 2.65		
R 8 = -8.87	D 8 = 1.25	N 4 = 1.805181	$\nu$ 4 = 25.4
R 9 = -12.60	D 9 = 0.70		
R10 = 56.47	D10 = 4.71	N 5 = 1.583126	$\nu$ 5 = 59.4
* R11 = -12.20	D11 = 可変		
* R12 = -12.63	D12 = 2.51	N 6 = 1.877800	$\nu$ 6 = 55.3
R13 = -180.39			

可変距離 可変距離	31.10	59.87	89.16
D 4	0.85	7.95	14.17
D 6	2.97	8.93	12.88
D11	11.18	4.23	1.28

## 非球面係数

11面

 $A=0$   $B=1.026 \text{ e-04}$   $C=-2.281 \text{ e-07}$   $D=2.601 \text{ e-08}$   $E=-2.721 \text{ e-10}$ 

12面

 $K=-4.937 \text{ e-01}$   $A=0$   $B=5.503 \text{ e-05}$   $C=4.380 \text{ e-07}$   $D=-4.160 \text{ e-09}$   $E=1.243 \text{ e-11}$ 

[0030]

[External Character 2]

## 数値実施例 2

 $f = 31.10 \sim 89.16$   $Fno = 3.91 \sim 8.71$   $2\omega = 69.7 \sim 27.3$ 

R 1 = 92.25	D 1 = 3.87	N 1 = 1.516930	$\nu$ 1 = 64.2
R 2 = -56.53	D 2 = 0.13		
R 3 = -52.69	D 3 = 1.50	N 2 = 1.805181	$\nu$ 2 = 25.4
R 4 = -975.07	D 4 = 可変		
R 5 = 13.36	D 5 = 3.47	N 3 = 1.621021	$\nu$ 3 = 35.3
R 6 = 19.12	D 6 = 可変		
R 7 = 絞り	D 7 = 2.65		
R 8 = -8.99	D 8 = 1.25	N 4 = 1.805181	$\nu$ 4 = 25.4
R 9 = -12.54	D 9 = 0.80		
R10 = 57.05	D10 = 4.71	N 5 = 1.589126	$\nu$ 5 = 59.4
* R11 = -12.36	D11 = 可変		
* R12 = -12.92	D12 = 2.51	N 6 = 1.677800	$\nu$ 6 = 55.3
R13 = -221.05			

可変距離	31.10	59.64	89.16
D 4	0.57	8.54	13.57
D 6	3.02	9.95	12.95
D11	11.19	4.26	1.27

## 非球面係数

11面

A=0 B=8.944 e-05 C=4.050 e-07 D=8.468 e-09 E=-1.212 e-10

12面

K=-4.367 e-01 A=0 B=5.317 e-05 C=5.018 e-07 D=-5.159 e-09 E=1.630 e-11

[0031]

[External Character 3]



## 数値実施例 3

 $f = 31.10 \sim 89.16$   $Fno = 3.91 \sim 8.87$   $2\omega = 69.7 \sim 27.3$ 

R 1 = 124.77	D 1 = 8.87	N 1 = 1.516330	$\nu$ 1 = 64.2
R 2 = -54.04	D 2 = 0.14		
R 3 = -49.90	D 3 = 1.50	N 2 = 1.805181	$\nu$ 2 = 25.4
R 4 = -584.11	D 4 = 可変		
R 5 = 13.40	D 5 = 3.47	N 3 = 1.621021	$\nu$ 3 = 35.3
R 6 = 20.18	D 6 = 可変		
R 7 = 絞リ	D 7 = 2.55		
R 8 = -9.02	D 8 = 1.25	N 4 = 1.805181	$\nu$ 4 = 25.4
R 9 = -12.66	D 9 = 0.61		
R10 = 58.06	D10 = 4.71	N 5 = 1.583126	$\nu$ 5 = 59.4
* R11 = -12.16	D11 = 可変		
* R12 = -12.80	D12 = 2.51	N 6 = 1.677900	$\nu$ 6 = 55.3
* R13 = -195.58			

焦点距離	31.10	59.86	89.16
可変距離			
D 4	1.00	7.70	13.66
D 6	2.98	9.97	12.98
D11	11.23	4.24	1.28

## 非球面係数

## 11面

 $A=0$   $B=1.020 \text{ e-04}$   $C=1.993 \text{ e-07}$   $D=1.204 \text{ e-08}$   $E=-1.437 \text{ e-10}$ 

## 12面

 $k=-2.715 \text{ e-01}$   $A=0$   $B=5.984 \text{ e-05}$   $C=8.269 \text{ e-07}$   $D=-4.540 \text{ e-09}$   $E=7.058 \text{ e-12}$ 

## 13面

 $A=0$   $B=-5.780 \text{ e-06}$   $C=9.172 \text{ e-08}$   $D=-3.338 \text{ e-10}$   $E=7.555 \text{ e-14}$ 

[0032]

[Effect of the Invention] according to this invention, constituting from four lens groups as a whole, and setting up appropriately migration conditions, refractive power, etc. of each lens group in variable power as mentioned above, -- the photography field angle of a wide angle edge -- about 70 degrees and a variable power ratio -- all the variable power ranges that are about 3.0 -- a rear spring supporter -- a zoom lens with high optical-character ability can be attained.

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## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The lens cross section of the numerical example 1 of this invention

[Drawing 2] The lens cross section of the numerical example 2 of this invention

[Drawing 3] The lens cross section of the numerical example 3 of this invention

[Drawing 4] Aberration drawing of the wide angle edge of the numerical example 1 of this invention

[Drawing 5] Middle aberration drawing of the numerical example 1 of this invention

[Drawing 6] Aberration drawing of the tele edge of the numerical example 1 of this invention

[Drawing 7] Aberration drawing of the wide angle edge of the numerical example 2 of this invention

[Drawing 8] Middle aberration drawing of the numerical example 2 of this invention

[Drawing 9] Aberration drawing of the tele edge of the numerical example 2 of this invention

[Drawing 10] Aberration drawing of the wide angle edge of the numerical example 3 of this invention

[Drawing 11] Middle aberration drawing of the numerical example 3 of this invention

[Drawing 12] Aberration drawing of the tele edge of the numerical example 3 of this invention

[Description of Notations]

L1 The 1st group

L2 The 2nd group

L3 The 3rd group

L4 The 4th group

SP Drawing

IP Image surface

d d line

g g line

S Sagittal image surface

M Meridional image surface

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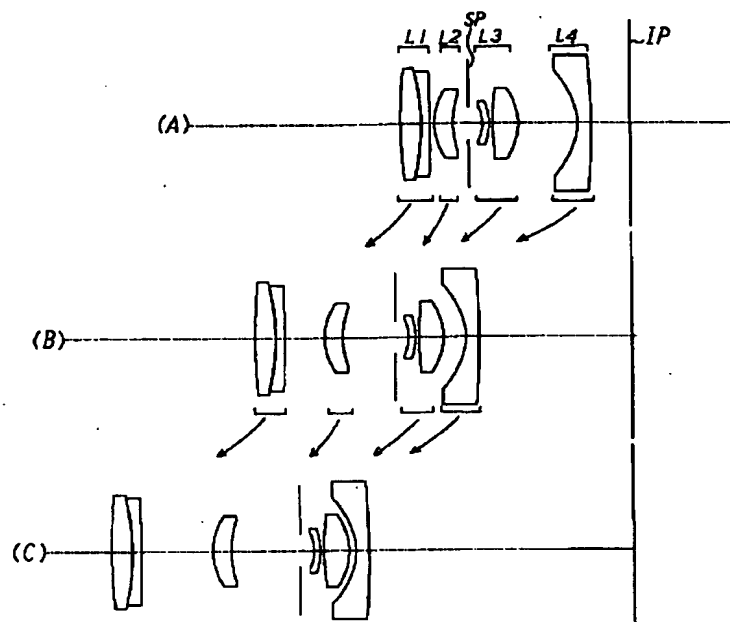
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DRAWINGS

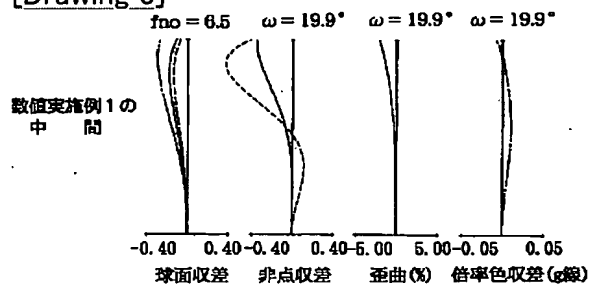
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[Drawing 1]

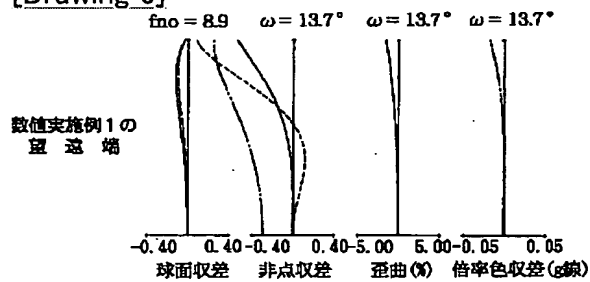




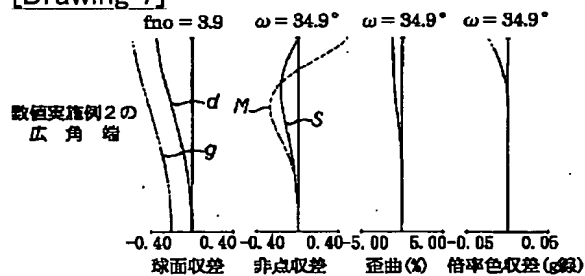
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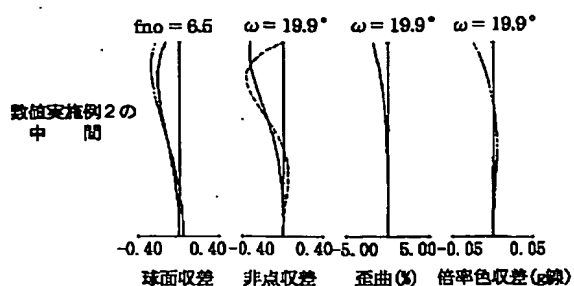
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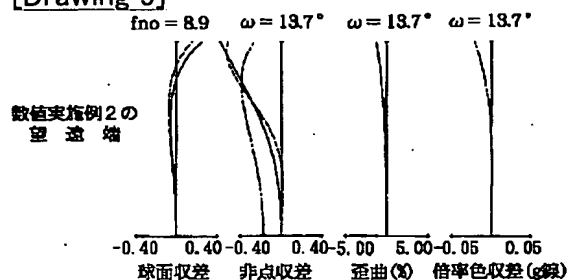
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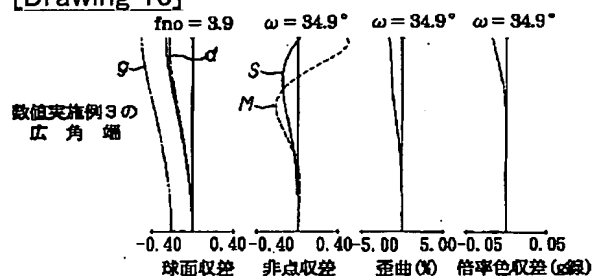
[Drawing 8]



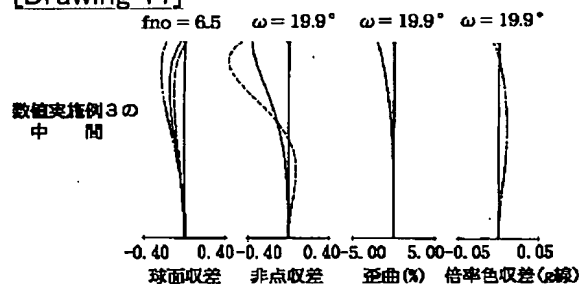
[Drawing 9]



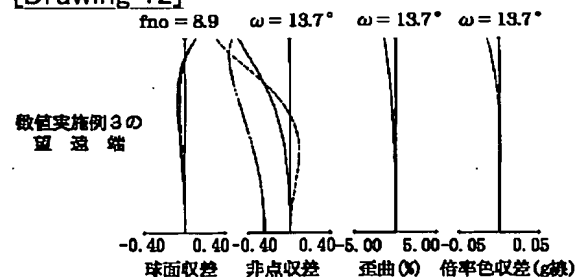
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Translation done.]

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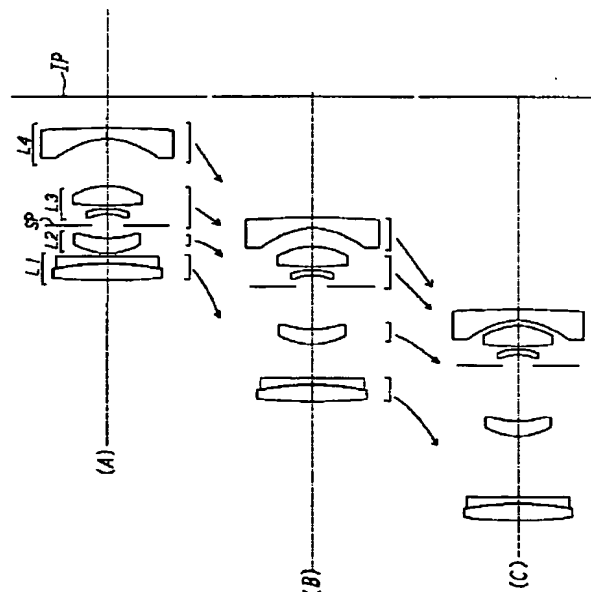
(74)代理人 弁理士 高梨 幸雄

(54)【発明の名称】 ズームレンズ

(57)【要約】

【課題】 全体として4つのレンズ群を有し、変倍に伴う収差変動を良好に補正した小型の4群ズームレンズを得ること。

【解決手段】 物体側より順に負の屈折力の第1群、正の屈折力の第2群、正の屈折力の第3群、そして負の屈折力の第4群の4つのレンズ群を有し、広角端から望遠端への変倍に際して該第1群と第2群の間隔及び該第2群と第3群の間隔が増大し、該第3群と第4群の間隔が減少するように各レンズ群が光軸上移動すると共に該第2群と第4群とが一体的に移動していること。



**【特許請求の範囲】**

【請求項1】 物体側より順に負の屈折力の第1群、正の屈折力の第2群、正の屈折力の第3群、そして負の屈折力の第4群の4つのレンズ群を有し、広角端から望遠端への変倍に際して該第1群と第2群の間隔及び該第2群と第3群の間隔が増大し、該第3群と第4群の間隔が減少するように各レンズ群が光軸上移動すると共に該第2群と第4群とが一体的に移動していることを特徴とするズームレンズ。

【請求項2】 前記第4群は物体側に凹面を向けた単一の負レンズより成り、該負レンズの少なくとも1つのレンズ面はレンズ中心からレンズ周辺部にいくに従い負の屈折力が弱くなる形状の非球面であることを特徴とする請求項1のズームレンズ。

【請求項3】 前記第3群は少なくとも1つの非球面を有していることを特徴とする請求項1のズームレンズ。

【請求項4】 前記第3群は変倍に伴い一体的に移動する絞りを有していることを特徴とする請求項1のズームレンズ。

【請求項5】 前記第3群を移動させてフォーカスを行っていることを特徴とする請求項4のズームレンズ。

【請求項6】 広角端から望遠端への変倍の際、前記第1群から第4群が全て物体側へ移動していることを特徴とする請求項1～5の何れか1項記載のズームレンズ。

【請求項7】 広角端から望遠端への変倍に際して前記第1群と第2群の移動量を各々 $M1$ 、 $M2$ としたとき $1.1 < M1/M2 < 1.6$

なる条件を満足することを特徴とする請求項1～6の何れか1項記載のズームレンズ。

**【発明の詳細な説明】****【0001】**

【発明の属する技術分野】本発明はレンズシャッターカメラ、ビデオカメラ等に好適な小型の高変倍で広画角のズームレンズに関し、特に撮影画角の広画角化を図ると共にレンズ全長（第1レンズ面から像面までの距離）の短縮化を図った携帯性に優れたズームレンズに関するものである。

**【0002】**

【従来の技術】最近レンズシャッターカメラ、ビデオカメラ等においては、カメラの小型化に伴いレンズ全長の短い小型のズームレンズが要求されている。

【0003】特にレンズシャッターカメラは、ズーム駆動用の電気回路などの周辺技術の発達などにより、増々カメラの小型化が進んでおり、それに備わる撮影レンズも高変倍でかつコンパクトなズームレンズが要求されている。

【0004】従来、レンズシャッター用のズームレンズとしては正、負の屈折力の2つのレンズ群より成る所謂2群ズームレンズが主流であった。この2群ズームレンズはレンズ構成及び変倍時の移動機構が簡易なため、カ

メラの小型化及び比較的低コストである等の利点がある。

【0005】しかしながら変倍作用を1つのレンズ群のみで行わなくてはならないため、その変倍比は1.6～2倍程度であり、無理に変倍比を拡大することはレンズ系的大型化を招くと同時に、高い光学性能を保つことが困難になってくる。

【0006】2群ズームレンズを基礎とし、第1群を正の屈折力の2つのレンズ群に分離し、全体として正、負の屈折力の3群構成として高変倍化を狙った3群ズームレンズが、例えば特開平3-282409号公報、特開平4-37810号公報、特開平4-76511号公報等で提案されている。

【0007】しかしながらこのレンズ群構成で例えば半画角 $35^\circ$ 以上の広画角なズームレンズ系を達成しようとすると変倍時の入射瞳位置の変化が大きくなる。このため、高変倍化を図る際は変倍による収差変動を抑えることが大変困難になってくる。

【0008】この他、多レンズ群化により広角端の半画角を $38^\circ$ 程度、変倍比を3.5倍程度とし、広画角化及び高変倍化を図ったズームレンズが、例えば特開平2-72316号公報、特開平3-249614号公報で提案されている。

【0009】しかしながら、これらのズームレンズ系は前玉径及びレンズ全長が共に大型であり、コンパクトカメラの撮影レンズとしては必ずしも十分でない。

【0010】特に外部ファインダーを使用するカメラに適用する際は、広角端時にレンズ鏡筒がファインダーの撮影視野を覆ってしまうという問題点がある。又この結果、ファインダー配置やカメラの形態の制限を与えてしまうという問題点も生じてくる。

【0011】又物体側から順に負、正、正、そして負の屈折力の4つのレンズ群より成り、比較的広画角で高変倍比の4群ズームレンズが、例えば特開平4-237009号公報で提案されている。しかしながらこの4群ズームレンズはレンズ枚数が多く、前玉径が増大する傾向があった。

【0012】又、特開昭64-15610号公報で提案されている4群ズームレンズは変倍比は3程度あるが、撮影画角が必ずしも十分でなかった。

**【0013】**

【発明が解決しようとする課題】一般にズームレンズにおいて各レンズ群の屈折力を強めれば所定の変倍比を得る為の各レンズ群の移動量が少なくなり、レンズ全長の短縮化を図りつつ高変倍化が可能となる。しかしながら単に各レンズ群の屈折力を強めると変倍に伴う収差変動が大きくなり、特に高変倍化及び広画角化を図る際には全変倍範囲にわたり良好なる光学性能を得るのが難しくなってくるという問題点がある。

【0014】本発明は、全体として4つのレンズ群より

構成し、変倍における各レンズ群の移動条件や屈折力等を適切に設定することにより、広角端の撮影画角が70°程度、変倍比3.0程度の全変倍範囲にわたり高い光学性能を有したズームレンズの提供を目的とする。

【0015】

【課題を解決するための手段】本発明のズームレンズは、物体側より順に負の屈折力の第1群、正の屈折力の第2群、正の屈折力の第3群、そして負の屈折力の第4群の4つのレンズ群を有し、広角端から望遠端への変倍に際して該第1群と第2群の間隔及び該第2群と第3群の間隔が増大し、該第3群と第4群の間隔が減少するように各レンズ群が光軸上移動すると共に該第2群と第4群とが一体的に移動していることを特徴としている。

【0016】

【発明の実施の形態】図1～図3は各々本発明の数値実施例1～3のレンズ断面図である。図1～図3において(A)は広角端、(B)は中間、(C)は望遠端を示している。図4～図6は本発明の数値実施例1の諸収差図、図7～図9は本発明の数値実施例2の諸収差図、図10～図12は本発明の数値実施例3の諸収差図である。

【0017】図中、L1は負の屈折力の第1群、L2は正の屈折力の第2群、L3は正の屈折力の第3群、L4は負の屈折力の第4群である。矢印は広角側から望遠端への変倍を行う際の各レンズ群の移動方向を示す。SPは絞り、IPは像面である。

【0018】本実施形態では広角端から望遠端への変倍に際して、第1群と第2群の間隔及び第2群と第3群の間隔が増大し、第3群と第4群の間隔が減少するように各レンズ群を光軸上物体側へ移動させている。これにより所定の変倍比及び広画角化を効果的に達成しつつ、レンズ系全体の小型化を図っている。

【0019】特に本発明では物体側より順に負の屈折力の第1群L1を両レンズ面が凸面の正レンズと物体側に凹面を向けた負レンズの2枚のレンズより構成し、正の屈折力の第2群L2を物体側に凸面を向けたメニスカス状の正レンズの1枚のレンズより構成し、正の屈折力の第3群L3を像面側に凸面を向けたメニスカス状の負レンズと両レンズ面が凸面の正レンズの2枚のレンズより構成し、負の屈折力の第4群L4を像面側に凸面を向けたメニスカス状の負レンズの1枚のレンズより構成している。これにより所定の変倍比を確保しつつ変倍に伴う収差変動を良好に補正し全変倍範囲にわたり高い光学性能を得ている。

$$X = \frac{(1/R) Y^2}{1 + \sqrt{1 - (1/K)(Y/R)^2}} + BY^4 + CY^6 + DY^8 + EY^{10}$$

なる式で表している。又「 $e^{-X}$ 」は「 $\times 10^{-X}$ 」を意味している。

【0020】又、前記第4群は物体側に凹面を向けた単一の負レンズより成り、該負レンズの少なくとも1つのレンズ面はレンズ中心からレンズ周辺部にいくに従い負の屈折力が弱くなる形状の非球面より構成し、変倍に伴う収差変動を補正し、特に像面湾曲や歪曲収差等の軸外収差を良好に補正している。又第3群は少なくとも1つの非球面を有するようにしている。これにより、変倍及びフォーカスの際の収差変動を良好に補正している。

【0021】絞りSPは変倍に伴い第3群と一体的に移動させて、各レンズ群のレンズ外径の増大を防止している。又第3群を移動させてフォーカスを行い、フォーカスの際の収差変動を少なくしている。

【0022】広角端から望遠端への変倍の際、前記第1群から第4群が全て物体側へ移動するようにして広角端でのレンズ全長の短縮化を図り、不使用のときのカメラ全体の小型化を図っている。

【0023】広角端から望遠端への変倍に際して前記第1群と第2群の移動量を各々M1、M2としたとき

$$1.1 < M1/M2 < 1.6 \quad \dots\dots (1)$$

なる条件を満足するようにしている。

【0024】条件式(1)は変倍に伴う第1群と第2群の移動量の比に関し、主にレンズ全長の短縮化を図りつつ、像面湾曲を良好に補正する為のものである。条件式(1)の上限値を越えて第2群に比べて第1群の移動量が多くなると、望遠端でのレンズ全長が長くなってくるので良くない。

【0025】又条件式(1)の下限値を越えて第1群の移動量が少なくなってくると、変倍に伴う収差変動、特に倍率色収差の変動を良好に補正するのが難しくなってくる。

【0026】尚、更に好ましくは条件式(1)の数値範囲を

$$1.2 < M1/M2 < 1.4 \quad \dots\dots (1a)$$

の如く設定するのが良い。

【0027】次に本発明の数値実施例を示す。数値実施例においてRiは物体側より順に第i番目のレンズ面の曲率半径、Diは物体側より第i番目のレンズ厚及び空気間隔、Niとniは各々物体側より順に第i番目のレンズのガラスの屈折率とアッペ数である。又、非球面形状はレンズ面の中心部の曲率半径をRとし、光軸方向(光の進行方向)をX軸とし、光軸と垂直方向をY軸、B、C、D、Eを各々非球面係数としたとき

【0028】

【数1】

【0029】

【外1】



## 数值实施例 1

 $f = 81.10 \sim 89.16$   $Fno = 3.91 \sim 8.87$   $2\omega = 69.7 \sim 27.3$ 

R 1 = 113.17	D 1 = 3.87	H 1 = 1.518330	$\nu$ 1 = 44.2
R 2 = -56.62	D 2 = 0.15		
R 3 = -61.75	D 3 = 1.50	H 2 = 1.805181	$\nu$ 2 = 25.4
R 4 = -1251.5	D 4 = 可変		
R 5 = 12.85	D 5 = 3.47	H 3 = 1.621021	$\nu$ 3 = 25.3
R 6 = 20.88	D 6 = 可変		
R 7 = 絞り	D 7 = 2.65		
R 8 = -2.67	D 8 = 1.25	H 4 = 1.805181	$\nu$ 4 = 25.4
R 9 = -12.60	D 9 = 0.70		
R10 = 56.47	D10 = 4.71	H 5 = 1.581126	$\nu$ 5 = 59.4
* R11 = -12.20	D11 = 可変	H 6 = 1.677900	$\nu$ 6 = 55.3
* R12 = -12.63	D12 = 2.51		
R13 = -180.39			

焦点距離	81.10	89.87	89.16
可変距離			
D 4	0.85	7.95	14.17
D 6	2.97	9.99	12.88
D11	11.18	4.23	1.23

## 非球面係数

## 11面

 $A=0$   $B=1.026 \text{ e-04}$   $C=-2.281 \text{ e-07}$   $D=2.601 \text{ e-08}$   $E=-2.721 \text{ e-10}$ 

## 12面

 $K=-4.937 \text{ e-01}$   $A=0$   $B=5.503 \text{ e-05}$   $C=4.380 \text{ e-07}$   $D=-4.160 \text{ e-08}$   $E=1.243 \text{ e-11}$

## 数値実施例 2

 $f = 31.10 \sim 89.16$   $Fno = 3.91 \sim 8.71$   $2\omega = 69.7 \sim 27.3$ 

R 1 = 92.25	D 1 = 3.87	N 1 = 1.516930	$\nu$ 1 = 64.2
R 2 = -56.59	D 2 = 0.13		
R 3 = -52.69	D 3 = 1.50	N 2 = 1.805181	$\nu$ 2 = 25.4
R 4 = -975.07	D 4 = 可変		
R 5 = 13.38	D 5 = 3.47	N 3 = 1.621021	$\nu$ 3 = 35.8
R 6 = 19.12	D 6 = 可変		
R 7 = 絞リ	D 7 = 2.65		
R 8 = -8.99	D 8 = 1.25	N 4 = 1.805181	$\nu$ 4 = 25.4
R 9 = -12.54	D 9 = 0.80		
R10 = 57.05	D10 = 4.71	N 5 = 1.588126	$\nu$ 5 = 59.4
* R11 = -12.26	D11 = 可変		
* R12 = -12.92	D12 = 2.51	N 6 = 1.677900	$\nu$ 6 = 55.3
R13 = -221.05			

<del>可変距離</del>	<del>焦点距離</del>	31.10	59.64	89.16
D 4		0.57	8.54	13.57
D 6		3.02	9.95	12.95
D11		11.19	4.26	1.27

## 非球面係数

## 11面

 $A=0$   $B=8.944 \text{ e-05}$   $C=4.050 \text{ e-07}$   $D=8.463 \text{ e-09}$   $E=-1.212 \text{ e-10}$ 

## 12面

 $K=-4.367 \text{ e-01}$   $A=0$   $B=5.317 \text{ e-05}$   $C=5.018 \text{ e-07}$   $D=-5.159 \text{ e-09}$   $E=1.630 \text{ e-11}$

## 数値実施例 3

$$f = 31.10 \sim 89.16 \quad Fno = 3.91 \sim 8.87 \quad 2\omega = 82.7 \sim 27.3$$

R 1 = 124.77	D 1 = 8.87	N 1 = 1.516330	$\nu$ 1 = 64.2
R 2 = -54.04	D 2 = 0.14		
R 3 = -49.90	D 3 = 1.50	N 2 = 1.805181	$\nu$ 2 = 25.4
R 4 = -594.11	D 4 = 可変		
R 5 = 13.40	D 5 = 3.47	N 3 = 1.621021	$\nu$ 3 = 35.8
R 6 = 20.18	D 6 = 可変		
R 7 = 絞リ	D 7 = 2.65		
R 8 = -9.02	D 8 = 1.25	N 4 = 1.805181	$\nu$ 4 = 25.4
R 9 = -12.55	D 9 = 0.61		
R10 = 58.08	D10 = 4.71	N 5 = 1.583125	$\nu$ 5 = 59.4
* R11 = -12.16	D11 = 可変		
* R12 = -12.80	D12 = 2.51	N 6 = 1.677900	$\nu$ 6 = 55.3
* R13 = -185.58			

<del>焦点距離</del>	31.10	59.85	89.16
<del>可変距離</del>			
D 4	1.00	7.70	18.65
D 6	2.98	9.97	12.93
D11	11.23	4.24	1.28

## 非球面係数

11面

$$A=0 \quad B=1.020 \quad e-04 \quad C=1.993 \quad e-07 \quad D=1.204 \quad e-08 \quad E=-1.487 \quad e-10$$

12面

$$K=-2.715 \quad e-01 \quad A=0 \quad B=5.984 \quad e-05 \quad C=6.269 \quad e-07 \quad D=-4.540 \quad e-09 \quad E=7.058 \quad e-12$$

13面

$$A=0 \quad B=-6.780 \quad e-06 \quad C=9.172 \quad e-08 \quad D=-3.338 \quad e-10 \quad E=7.555 \quad e-14$$

## 【0032】

【発明の効果】本発明によれば以上のように、全体として4つのレンズ群より構成し、変倍における各レンズ群の移動条件や屈折力等を適切に設定することにより、広角端の撮影画角が70°程度、変倍比3.0程度の全変倍範囲にわたり高い光学性能を有したズームレンズを達成することができる。

## 【図面の簡単な説明】

【図1】本発明の数値実施例1のレンズ断面図

【図2】本発明の数値実施例2のレンズ断面図

【図3】本発明の数値実施例3のレンズ断面図

【図4】本発明の数値実施例1の広角端の収差図

【図5】本発明の数値実施例1の中間の収差図

【図6】本発明の数値実施例1の望遠端の収差図

【図7】本発明の数値実施例2の広角端の収差図

【図8】本発明の数値実施例2の中間の収差図

【図9】本発明の数値実施例2の望遠端の収差図

【図10】本発明の数値実施例3の広角端の収差図

【図11】本発明の数値実施例3の中間の収差図

【図12】本発明の数値実施例3の望遠端の収差図

## 【符号の説明】

L1 第1群

L2 第2群

L3 第3群

L4 第4群

SP 絞リ

IP 像面

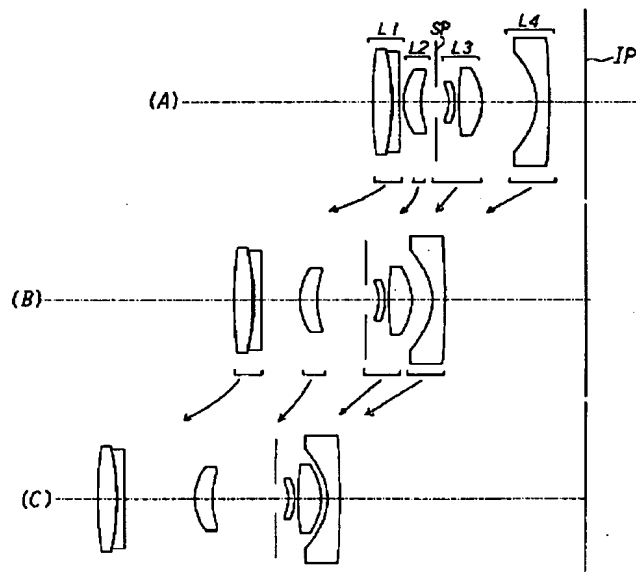
d d線

g g線

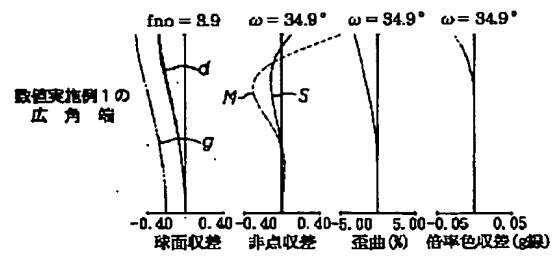
S サジタル像面

M メリディオナル像面

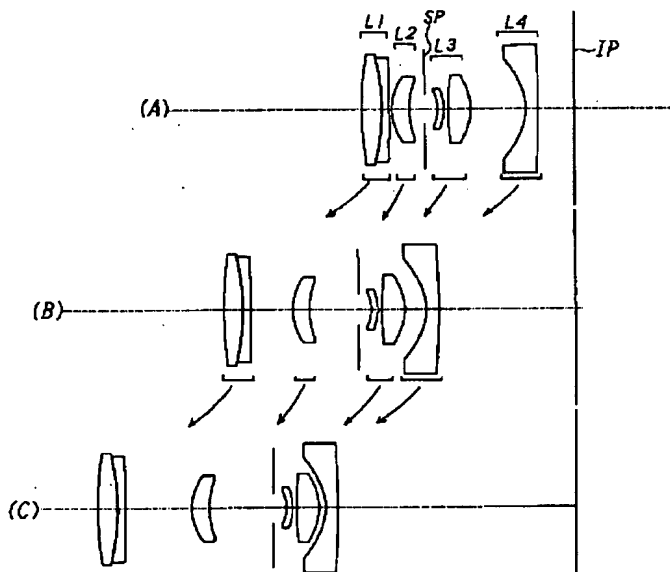
【図1】



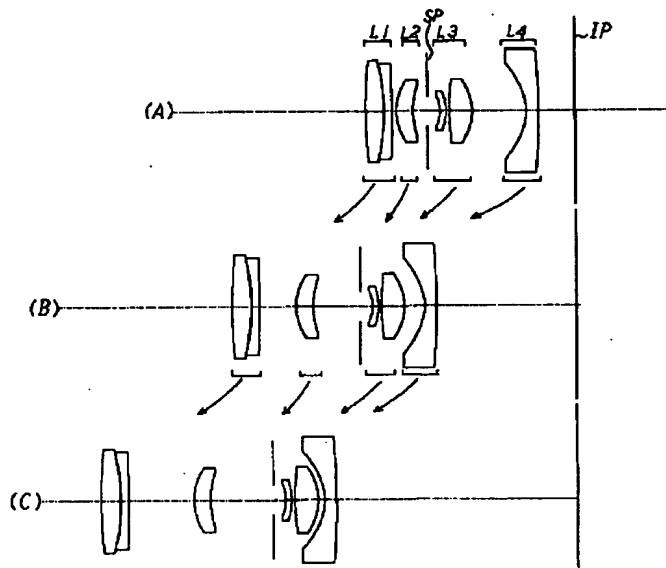
【図4】



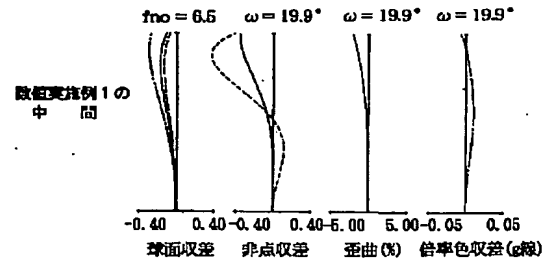
【図2】



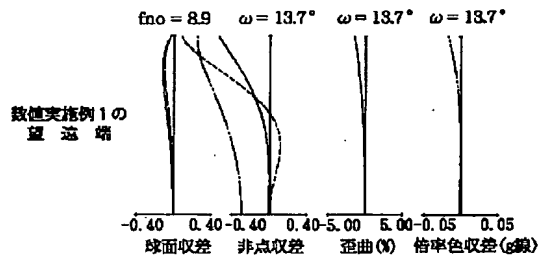
【図3】



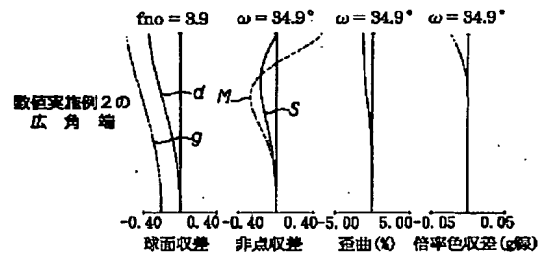
【図5】



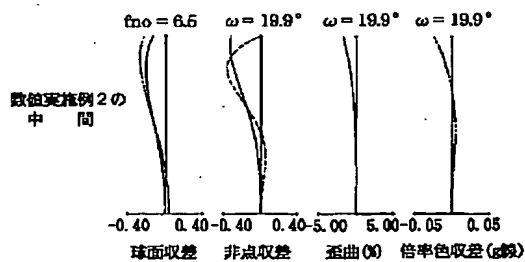
【図6】



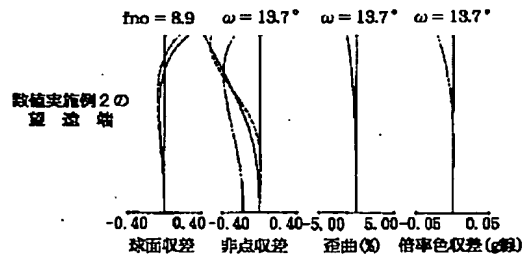
【図7】



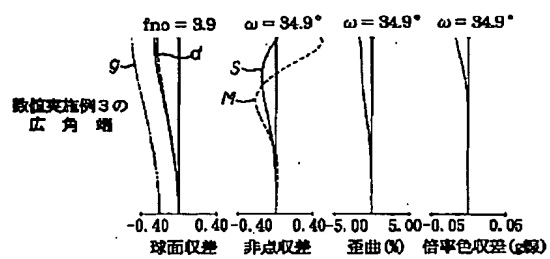
【図8】



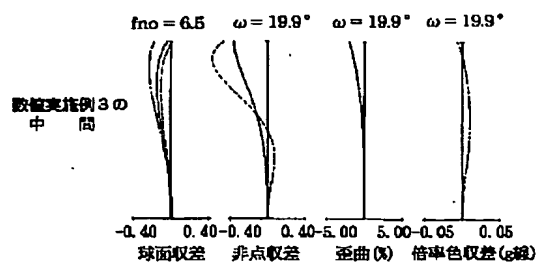
【図9】



【図10】



【図11】



【図12】

